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ABSTRACT

There is little doubt that the findings of research in science education can be depressing at times. The literature is replete with reports and research findings which highlight problems and shortcomings associated with the teaching and learning of science. In order to provide a refreshing alternative to the majority of research reports which malign science education and highlight its major problems and shortcomings, a series of case studies of exemplary practice in science teaching was initiated in three nations to provide a focus on the successful and positive facets of schooling. It was assumed that much could be learned from case studies of exemplary practice that would stimulate and guide improvements in science education, especially with such an international perspective. This symposium was designed to permit the first comparison and discussion of results in Australia, Israel, and the United States. Included are three papers entitled "Case Studies of Practices Used by Exemplary Science and Mathematics Teachers," (Barry Fraser and David Treagust, Australia); "Research on Exemplary Chemistry Teachers in Israel," (Avi Hofstein, Israel); and "The Practices of Teachers Who Develop Exemplary Science Programs," (Robert E. Yager and Ronald J. Bonnstetter, United States). (CW)

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THE NATURE OF "EXEMPLARY" SCIENCE TEACHERS: IMPLICATIONS FOR TEACHER EDUCATION

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Abstract

There is little doubt that the findings of research in science education can be depressing at times. The literature is replete with reports and research findings which highlight problems and shortcomings associated with the teaching and learning of science (Stake & Easley, 1978; National Commission on Excellence in Education, 1983; National Science Board, 1983; Goodlad, 1984; Tobin & Gallagher, 1987). In order to provide a refreshing alternative to the majority of research reports which malign science education and highlight its major problems and shortcomings, a series of case studies of exemplary practice in science teaching was initiated in three nations to provide a focus on the successful and positive facets of schooling. It was assumed that much could be learned from case studies of exemplary practice that would stimulate and guide improvements in science education, especially with such an international perspective.

In contrast to the research which casts a gloomy picture over schooling, especially science education, there have been some more optimistic research endeavors in recent times which highlight educational accomplishments and pave the way for improvements in schooling. For example, the effective schools movement (Bickel, 1983, Lezotte, 1989) is premised on the assumption that successful schools do exist and that other schools could be improved by adopting some of the practices found in effective schools. Berliner (1986) strongly recommended the study of expert teachers as a means of obtaining useful case material with potential applications in preservice and inservice courses for teachers. In the specific field of science education, Penick and Yager (1983) concluded that past case studies only highlighted the plight of science education and held little promise for stimulating improvements. Consequently, they advocated studies with a focus on successful science education as holding hope for improving practice. These ideas were incorporated into a project known as the Search for Excellence which began in 1982 under the sponsorship of the National Science Teachers Association, the Council of State Supervisors, the National Science Supervisors Association, and the National Science Board (Penick & Yager, 1983; Yager, 1984).

Because the Search for Excellence and other studies based on a similar philosophy had caused considerable excitement, optimism, and motivation among teachers, researchers in Australia and Israel decided to conduct somewhat similar research efforts. U.S. Search for Excellence, and the two

other studies focused on the classroom practices employed by exemplary teachers rather than those of teachers of exemplary programs. These later studies were committed to intensive classroom observations of the exemplary teachers involved in the studies. The symposium will permit the first comparison and discussion of results in these three nations.

Introduction

Bickel (1983) and Lezotte (1989) have led the so-called effective schools movement. These efforts have assumed that successful schools and teachers do exist and that improvement in others can occur if the practices utilized in the most effective situations are tried. Berliner (1986) has recommended this study of outstanding teachers as a way of improving teacher education. Major studies have occurred in science education which have followed these lines of reasoning.

The proposed symposium presenters and the discussant have been involved with identifying exemplary science programs and teachers in the U.S. (the NSTA Search for Excellence Project), Western Australia (Exemplary Practices in Science and Mathematics Project), and Israeli (Exemplary Secondary Teachers of Chemistry Project). Although the population of teachers selected in each nation was selected by different criteria, the aim of identifying the "best" teachers of science at the secondary level was similar.

The presenters involved with the research in the U.S., Australia, and Israel have been directly involved in the identification of exemplary teachers, programs, and practices. All have been involved with extensive on-sight case studies in schools where exemplary teachers have been found. The symposium will provide an opportunity to analyze differences and similarities with respect to approach, findings, and use of the new information.

As indicated previously the results of such studies can be useful in stimulating other schools and teachers to change. The generalizations possibly can suggest new research to test the interpretations made. Also such results can (and should) affect pre-service programs and in-service efforts with all teachers of science.

Case Studies of Practices Used by Exemplary Science and Mathematics Teachers

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Case Studies of Practices Used by

Exemplary Science and Mathematics Teachers

In Australia an interpretive research methodology (Erickson, 1986) was used in the study. The data were primarily qualitative and were obtained by: direct observation of at least eight lessons by participant observers; interviews with teachers and students; and examination of curriculum materials, tests, and student work. Altogether, approximately 300 hours of intensive observation of science classrooms were involved. Initially, the questions guiding the research were broad (e.g., What characterizes exemplary science teachers and their classes?). However, as data were collected, they were analyzed and interpreted for the purpose of guiding new data collection strategies aimed at seeking convincing answers to the emerging questions. As a consequence, each case study became more focused as questions arose and new data collecting strategies were planned to seek answers to the questions.

Throughout the study, meetings of the research team were held to facilitate discussion of administrative matters and substantive issues related to interpretation. Analysis and interpretation occurred within three teams: the researchers involved in each case study (i.e., one or two researchers in most case studies); the nine researchers involved in the seven science case studies; and the 14 researchers involved in the 12 science and mathematics case studies. At regular intervals during the data collection phase, field notes were discussed by the researchers and assertions consistent with the observations were formulated. Subsequent observations were used as a basis for refuting, revising, and/or accepting assertions. The criterion for acceptance was s decisive balance of probabilities favoring the assertions. The accuracy and representativeness of the observations and the validity of the findings were of prime concern. In particular, evidence for and against assertions were presented during team meetings. Generally, evidence for assertions was based on more than one data source and researcher, and assertions supported by one case study were investigated in the other case studies as well.

In addition to the qualitative information, quantitative information also was gathered by assessing student perceptions of the psychosocial learning environment (Fraser, 1986) with a variety

of questionnaires selected from Fraser and Fisher (1983). The measures provided a quantified picture of life in the classrooms of exemplary teachers as perceived by students and enabled comparisons to be made between the learning environments in classes taught by exemplary and non-exemplary science teachers.

Findings

The results indicated that there was considerable diversity in the methods used by these exemplary teachers and in the learning environments prevalent in their classes. Furthermore, each case study was conducted by one or two researchers who interpretive frameworks inevitably shaped what was observed, recorded, and interpreted. As a consequence, synthesizing the findings of the seven studies is a potentially hazardous undertaking which is approacher with considerable caution. The findings of the study are described below in terms of four assertions which applied to the classes taught by each of the exemplary science teachers.

Assertion 1: Exemplary teachers used management strategies which facilitated sustained student engagement. A distinctive feature of the classes of the exemplary science teachers was the high level of managerial efficiency. For example, when Tobin (1987) compared the teaching performance of two high school science teachers with that of colleagues teaching in the same schools, the main feature which differentiated the exemplary teachers from their colleagues was the management of their classes. The exemplary teachers had well-ordered classes with a relaxed atmosphere characterized by pleasant interactions with students and subtle use of humor. In an important sense, management was the key to success because the exemplary teachers were able to concentrate on teaching and learning rather than on keeping control of student behavior. Although different styles were used by different exemplary teachers in establishing and maintaining an environment which was conducive to learning, in all case studies the crucial link between management, teaching, and learning was highlighted.

Assertion 2: Exemplary teachers used strategies designed to increase student understanding of science. A finding which applied to most of the exemplary teachers was that they had a concern for assisting students to learn with understanding. As a consequence, the teachers set up activities in which students could have overt involvement in the academic tasks. In elementary grades, the

activities were based on the use of materials to solve problems and, in high school grades, teachers often used concrete exemplars for abstract concepts. However, the key to teaching with understanding was the verbal interaction which enabled teachers to monitor student understanding of science concepts. The exemplary teachers were effective in a range of verbal strategies which included asking questions to stimulate thinking, probing student responses for clarification and elaboration, and providing explanations to provide students with additional information.

The importance of content knowledge of the teacher was well illustrated in a negative sense by Happs (1987) study of two exemplary science teachers teaching a general science topic outside of their field of expertise. His results call into question the assumption that nay science teacher can teach any general science topic effectively. The major problem highlighted by Happs was the difficulty faced by teachers in diagnosing student misconceptions and providing suitable cues to enable students to develop alternative conceptions. In one case study, a student misconception actually was reinforced by inappropriate use of the analogy of thickness for the concept of density. f the teacher had a greater understanding of density, he might have anticipated the misconception and selected an analogy that would assist students to understand relationships between density and flotation. An associate problem addressed by Happs was that of an "exemplary" teacher presenting incorrect information to the class. He pointed out that errors in the content presented by teachers can result in student misunderstandings which might be difficult to change because of the students' faith in the validity of knowledge provided by "a dynamic, forceful and convincing teacher".

Assumption 3: Exemplary teachers utilized strategies which encouraged students to participate in learning activities. Sanford (1987) explained how safety net can be used by teachers to allow students to participate without undue embarrassment in from of the teacher and their peers. In the classes of most exemplary science teachers, safety nets were used to encourage involvement from all students. Although involvement was maximized, the cognitive level of the work was maintained at an appropriately high level. Teachers appeared able to make it safe for students to engage in whole-class, small-group, and individualized activities and maintain a focus on meaningful learning. For example, an exemplary biology teacher always treated students and their contributions with the utmost respect and endeavored to work from a given answer to the understanding that he wanted a

student to have. After teacher explanations, he offered all students a chance to request further explanation or clarification and encouraged questions with comments such as "I don't want to embarrass you, I want to help you understand." When students were unable to respond to a question, this teacher usually persisted by rephrasing the original question or asking supplementary questions until the student could contribute.

Assumption 4: Exemplary teachers maintained favorable classroom learning environments. In an attempt to make meaningful interpretations of the learning environment data collected as part of the Exemplary Practice in Science and Mathematics Education study, the actual environments of exemplary teachers' classes were compared, first, with the actual environment of comparison groups of classes from past research, second, with the class environment preferred by the exemplary teachers' students and third, with the actual classroom environment of non-exemplary teachers of the same grade levels within the same schools. Overall, the results provide considerable evidence suggesting that, first exemplary and non-exemplary science teachers can be differentiated in terms of the psychosocial environments of their classrooms as seen through their students' eyes and, second, that exemplary teachers typically create classroom environments that are markedly more favorable than those of non-exemplary teachers. A sample of the classroom environment findings, which are reported in greater detail by Fraser and Tobin (in press), are provided below.

An earlier report illustrates how the students in the grade 11 class of an exemplary biology teacher (Tobin, Treagust, & Fraser, 1988) perceived their actual classroom climate considerably more favorable than the way that the comparison group viewed their science classes in terms of the six dimensions of the short form of the Classroom Environment Scale (CES) described previously. The comparison group consists of the 116 junior high school science classes described previously. It is clear that the exemplary teacher's students perceived their classroom environment considerably more favorably than the way that the comparison group viewed their classes. In particular, these differences were most marked in terms of high levels of Involvement, Teacher Support, and Order and Organization.

The differences between the exemplary teacher's classroom environment and those perceived by the comparison group can be expressed in terms of "effect sizes" (i.e., as the number of standard

deviations for the comparisons group). The means and standards obtained on each CES scale by the exemplary biology teacher's class were computed; these were compared with the means and standard deviations for the comparison group. Effect sizes were all quite large, with values ranging from 1.0 for Affiliation to 2.2 for Involvement. In other words, for the Involvement scales, the mean for the exemplary teacher was 2.2 standard deviations for class means above the comparison group.

Another way of interpreting the exemplary biology teacher's classroom environment data involved a comparison of the actual environment of this class with this class's preferred classroom environment. Past research evidence from both science and non-science classes (Moos, 1979; Fraser, 1982; Fisher & Fraser, 1983) clearly indicates a patter in which students' preferred classroom environment is consistently more positive than the environment perceived to be actually present. Consequently, the results depict a quite atypical classroom in which there is a congruence between actual and preferred environment on as many as five of the CES's six scales. The only exception to this pattern is that students would prefer more Teacher Support (even though the level of Teacher Support perceived to be actually present is much higher than in the comparison group). Clearly, the comparisons of actual and preferred environment as perceived by students in the exemplary teacher's classes provides further evidence about the favorableness of the classroom environments created by this exemplary biology teacher.

Fraser and Tobin (in press) also reported use of the CES in a comparison of an exemplary science teacher with several other science teachers at the same private school. The results clearly show that the exemplary science teacher's students perceive their classroom environment more positively than the way in which the non-exemplary science teachers students view their classes. Sizeable differences of approximately three-quarters of a standard deviation existed between the exemplary and the non-exemplary teachers' classes on the four dimensions of Teacher Support, Task Orientation, Order and Organization, and Rule Clarity.

Overall, these findings from a comparison of an exemplary and some non-exemplary science teachers within the same school replicate the results obtained by contrasting exemplary teachers' classroom environments with those of large comparison groups in previous research. The use of these two alternative approaches provides an important validity check and strongly supports the general

finding that exemplary and non-exemplary teachers can be differentiated in terms of the more favorable perceptions of classroom environment held by exemplary teachers students. Discussion of these findings in Western Australia provide important information for teacher educators. Such implications will be included as an important part of the symposium discussion and analysis.

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Research on Exemplary Chemistry Teachers in Israel

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Research on Exemplary Chemistry Teachers in Israel

Introduction

In the last decade, following the 'golden age' of science curriculum development and implementation, a vast amount of research was conducted in the context of science education. The main goals of these studies was to improve schooling, teaching techniques, to increase students motivation to learn science and to obtain information on students cognitive and affective traits. Most of the studies that were conducted were based on the ex post factum method namely to obtain information on input and output of the science classroom. Information on what teachers are really doing in their science classrooms remains scare.

In recent years, the "Exemplary Teachers" approach is an area that was found to be most promising to discern what teachers are really doing in their classrooms, while trying to translate the intentions and goals of science curriculum developers into the classroom situation (Penick & Yager, 1983; Tobin & Fraser, 1987).

Rationale for the study

Despite the great effort to improve science curricula around the world, there is a great concern with the problem of low enrollment in high school science courses. For example, in a study conducted in the U.S., it was found that eighty-two percent of tenth graders are enrolled in science but less than half of the juniors and only a third of the seniors sign up for any science (Welch, Harris, & Anderson, 1984). Familiar concerns regarding enrollment in science courses have been raised in Israel (Dvoretzky, 1983). A research project conducted in an attempt to explore factors that influence students' decisions concerning the enrollment in chemistry courses in their last compulsory phase of education was made (Milner, Ben-Zvi, & Hofstein, 1987). In this study it was clearly found that the most predominant and influential factor concerning students' enrollment in chemistry is the one that deals with students' attitudes toward and interest in school chemistry.

Purpose of the study

The purpose of the present study was to investigate and document classroom practices of chemistry teachers in Israel. It was hoped that an analysis of the chemistry classroom behaviors

and practices and student perception of the classroom learning environment would elucidate our knowledge concerning students' decision about enrollment in such school chemistry courses.

More specifically this study aimed at obtaining information of exemplary as opposed to non-exemplary teachers concerning the following variables:

1. Teachers' classroom behavior and management; and
2. Enrollment of students in further chemistry courses.

RESEARCH METHOD

Selection of chemistry teachers

Eleven teachers who taught chemistry in twenty 10th grade classes were selected to participate in this study. The selection of teachers was based on information obtained from previous studies conducted by the chemistry curriculum development group (Ben Zvi & Hofstein, 1985) in the Department of Science Teaching at the Weizmann Institute of Science (a branch of the Israel Science Teaching Center). All the teachers who participated in this study used the same curriculum material, Chemistry-A Challenge. (For more details about this program, see Ben-Zvi, Eylon, & Silberstein, 1986.)

RESULTS AND DISCUSSION

Part 1: Teachers behavior in the chemistry classroom

In order to obtain information on classroom behavior and practice, five observers who are experienced chemistry teachers and involved in curriculum development observed these teachers during eight class and laboratory periods (over a period of 8-10 weeks). During this period all the classes were taught the same chemistry topics and concepts.

The observers used observation schedules in which the focus was on classroom activities and learning environment. The following data and information were collected:

1. Teaching strategies used in the chemistry classroom to obtain meaningful learning (i.e., demonstrations, laboratory techniques).
2. The use of models and other audiovisual aids.
3. The cognitive demands and methods used in order to obtain greater student understanding of the various chemistry topics.

4. Type of teacher-student interactions that may enhance learning.

5. Classroom management strategies (i.e., to identify those criteria that enable chemistry teachers to be successful classroom managers).

On the basis of these classroom observations it was possible to draw a profile of classroom practice of chemistry teachers. Although teachers have their own way of teaching and personal characteristics which differentiate one teacher from others, seven teaching modes, traits, characteristics were identified which enabled the investigators to identify exemplary and non-exemplary chemistry teachers. The traits are summarized in Table 1.

Table 1

Characteristics of Exemplary and Non-Exemplary Teachers

Variable	Exemplary teachers (N=4)	Average Teachers (N=7)
Confidence in and control over the learning material	+	-
Level of explanation	clear and focused	not clear and focused
Preparation of lesson	prepared with a rationale	confused
Awareness to cognitive difficulties	high	low
Awareness to individual progress	high	low
Method of teaching/instruction	encourages critical thinking, curiosity, interest	routine learning and not interesting
Relevance to topics learned previously	high	low

Part 2: Enrollment in a chemistry course

One school was chosen as a case study for further investigation of teacher's behavior and for the purpose of documentation of student enrollment in further chemistry courses in the last compulsory phase of their high school education.

In this school two chemistry teachers taught tenth grade chemistry (the compulsory phase of education). Both teachers have a strong background in chemistry and experience in teaching chemistry in grade ten. The two had preservice training in chemical education and were deeply involved in preservice training programs. They taught chemistry in the same school with the same teaching facilities and the same school learning environment.

Teacher A taught chemistry in two tenth grade classes: a science oriented class and a humanistic (non-science oriented) type of class. In general, the humanistic stream is usually populated with students who have low motivation to study chemistry.

Teacher B taught chemistry only in a science oriented class. Information on student enrollments at further (and more) advanced courses was obtained.

Table 2

Distribution of Student Enrollment in Chemistry Courses

Chemistry Teacher	Type of Tenth Grade	Percentage of Students enrolled in 3 credit* chemistry course	Percentage of Students enrolled in 5 credit** chemistry course	Percentage who did not enroll in a chemistry course
A	Science Oriented	17	48	35
A	Humanistic	23	30	47
B	Science Oriented	8	11	81

* average level chemistry course
** high level chemistry course

From the table it is clearly seen that enrollment in the science-oriented class taught by Teacher A is significantly higher compared to the one taught by Teacher B. Moreover, Teacher A managed to accomplish enrollment in advanced chemistry courses even in a humanistic type class. This information called for a more intensive and detailed analysis of the teachers' classroom behavior and teaching practice. More details and information will be presented concerning these facets. More specifically, descriptions of the two teachers include such factors as:

- classroom management,
- sensitivity to student learning difficulties and cognitive hetrogenity,
- language used in the classroom,
- the use of teaching/learning models, and
- method of teaching and interaction with students.

The most predominant factor that contributes to student understanding of chemistry, as well as to their motivation to learn chemistry, is the teacher's sensitivity to differences, both cognitive and affective, of his/her students. While the exemplary teacher did her utmost to attract as many students as possible, the non-exemplary one taught without any attention to whether students participated in the classroom activities or not.

An important characteristic of the exemplary teacher was the emphasis she placed on presenting the subject matter in a manner that facilitated student understanding. She did so by presenting the subject matter in a way that provided continuous feedback on student understanding and/or learning difficulties. While there was evidence that the non-exemplary teacher prepared her lesson in advance, the method and models she utilized in her classroom failed to arouse interest and motivation in her students. Very often the model used created even more confusion among the students.

We often hear complaints concerning low enrollments in the sciences. This study clearly shows that while curriculum developers should assess and redefine the goals of science teaching from time to time, teacher training institutions (both preservice and inservice) need to train their teachers to be more sensitive to:

1. the problem of differences among students;
2. methods of presentation of subject matter to avoid learning difficulties; and
3. the use of proper learning/teaching models.

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The Practices of Teachers Who Develop Exemplary Science Programs

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The Practices of Teachers Who Develop Exemplary Science Programs

Harms and Yager (1981) reported on the results of Project Synthesis, an NSF supported research effort designed to synthesize indicators of a Desired State in science education and the Actual State of science education as determined by the NSF status studies and the 1978 results of the Third Assessment of Science by the National Assessment of Educational Progress (Helgeson, Blosser, & Howe, 1977; NAEP, 1978; Stake and Easley, 1978; Weiss, 1978). Basic to the Project Synthesis design were four goal clusters (justifications) for school science; these included:

1. **Science for Meeting Personal Needs.** Science Education should prepare individuals to use science for improving their own lives and for coping with an increasingly technological world.
2. **Science for Resolving Current Societal Issues.** Science education should produce informed citizens prepared to deal responsibly with science-related societal issues.
3. **Science for Assisting with Career Choices.** Science education should give all students an awareness of the nature and scope of a wide variety of science and technology-related careers open to students of varying aptitudes and interests.
4. **Science for Preparing for Further Study.** Science education should allow students who are likely to pursue science academically as well as professionally to acquire the academic knowledge appropriate for their needs.

The Desired State conditions for Project Synthesis became the criteria for Excellence as the National Science Teachers Association sought to identify Exemplary Science Programs in U.S. schools (NSTA, 1987).

Another NSF project was awarded to NSTA as a part of the National Science Board effort to produce the report Educating Americans for the 21st century (NSB, 1983). Two special monographs were produced with these funds (Yager, 1983; Bonnstetter, Penick, & Yager, 1983). One was a series of case studies describing the situation in six districts which were identified as meeting criteria of excellence in two or more categories (Yager, 1983). The second was a study of the teachers involved with the fifty exemplary programs identified in 1983 (Bonnstetter, 1983; Bonnstetter, Penick, & Yager, 1983). The Case Studies and the survey of 216 teachers from exemplary programs revealed many specific features of these special groups of teachers.

In 1983 an Honors Workshop was awarded to the University of Iowa by NSF (Yager, 1988). This three year study funded by a million dollar grant permitted direct work with 861 teachers during the summers and following academic years. Much was learned about such teachers who were considered exemplary because of the programs they had produced or their extraordinary professional involvement.

This work was followed by still another NSF grant that included work with 600 Iowa teachers who became active in Science/Technology/Society efforts. A total of 30 teachers who have become most involved have formed a cadre of Lead Teachers. Their involvement as a part of in-service staff teams and our observations of their teaching during extended visitations in their own communities have produced additional information about exemplary science teachers and the results of their work with K-12 students.

The study of 114 K-6 teachers and 102 7-12 teachers identified as the architects of the first fifty NSTA Excellence Programs revealed the following characteristics of "exemplary" science teachers; they:

1. Provide a stimulating environment;
2. Create an accepting atmosphere;
3. Expect different students to achieve differently;

4. Put in far more than minimal time;
5. Have high expectations of themselves;
6. Challenge students beyond ordinary school tasks;
7. Are themselves models of active inquiry;
8. Do not view classroom walls as a boundary;
9. Frequently use societal issues as a focus;
10. Work easily with community leaders, administrators, and parents;
11. Are extremely flexible in their time, schedule, curriculum, expectations, and view of themselves;
12. Are concerned with developing effective communication skills;
13. Provide systematically for reflection, and assessment;
14. Require considerable self-assessment of their students;
15. Ask questions, expecting to hear new, and often unpredicted, answers;
16. Expect students to question facts, teachers, authority, and knowledge;
17. Encourage pragmatism;
18. Stress science literacy;
19. Want students to apply knowledge;
20. Do make a difference.

The final report to NSB ended with the statement that it is important that a critical mass of teachers with such characteristics be assembled.

The Iowa Honors Workshop produced a list of generalizations concerning the 861 exemplary teachers who were selected to participate in the program and who had most of the characteristics listed above. These included:

1. Successful teachers are available and anxious to be involved in leadership development projects;
2. Exceptional teachers can develop skills and interests needed for heading workshops for other teachers;
3. Teachers of exceptional programs are able to collaborate and to produce exemplary teaching modules for others to use;
4. Exemplary teachers develop expertise in applying for competitive awards, projects, and grants;
5. Exemplary teachers participate to a greater degree in in-service projects, especially those focusing upon new curriculum and new teaching strategies;
6. Exemplary teachers can become proficient as authors of professional manuscripts; such activity can become an important means for communication and recognition.

The case studies of the six districts with multiple exemplary programs produced results which indicated that the science teachers responsible had traits in common. These included:

1. Exemplary teachers have great enthusiasm;
2. Exemplary teachers have boundless energy;
3. Exemplary teachers are discontented with the status quo;
4. Exemplary teachers are active professionally;
5. Exemplary teachers are concerned with constant renewal.

The inservice efforts and leadership development activities in Iowa have resulted in changes in specific teaching strategies, as the teachers continue to develop and their teaching philosophies and styles change. The following list shows the contrasts:

Standard	Exemplary
Teachers work in their classroom with several sections of students assigned to them	Teachers work as part of a staff team working toward common goals

Teachers feel tied to textbook and/or a curriculum guide	Teachers look beyond the boundaries of a textbook and/or curriculum guide; they define minimal concept and activities used
Teachers are discipline bound; they rarely work competently with teachers from other curriculum areas -- or science teachers from disciplines other than their own	Teachers are constantly seeking linkages with others in the total school; they also seek linkages with other teachers in the state and nation
Teachers tend to distrust the use of experts from the community (external to the school)	Teachers see themselves (and their students) as reaching into the community for information, expertise, ideas, and materials
Teachers are seen as dispensers of information they possess	Teachers are seen as learners themselves and as facilitators and collaborators in student learning
Teachers rarely think about goals for science teachers; they rarely enter into debate or meaningful dialogue about their teaching	Teachers are anxious to share their philosophies as they seek ways of expanding their thinking; they seek information that will help them improve teaching
Teachers complain about in-service learning opportunities	Teachers seek out in-service assistance as they seek to grow and to improve

Teachers who are armed with a vast quantity of strategies for effective teaching are able to perform in ways that permit instructional goals to be met. Their students are able to use the concepts and processes of the science they encounter better than students found in traditional classes. In addition, their students have superior attitudes concerning science and science learning. Further, the students demonstrate significantly better creativity skills related to questioning, suggestions of causes, and predictions of consequences. Such student growth is encouraging as they are related to teacher traits that produce them.

Yager and McCormack (1989) have identified five domains for science teaching and assessment. The use of these domains permits comparison of student outcomes in each when taught by a traditional/standard teacher and when taught by an exemplary teacher. The contrast may help with establishing criteria which distinguish between typical teachers and exceptional ones. The following contrasts have been observed.

Classrooms Taught by Typical Teacher	Classrooms Taught by Exemplary Teacher
<u>Concepts</u>	
1. Concepts are really materials to be mastered for a teacher test	1. Students see science concepts as personally useful
2. Concepts are seen as an outcome themselves	2. Concepts are seen as a needed commodity for dealing with problems
3. "Learning" is principally for testing	3. Learning occurs because of activity; it is an important happening but not a focus in and of itself
4. Retention is very short lived	4. Students who learn by experience retain it and can often relate it to new situations

		Process	
1.	Students see science processes as skills scientists possess	1.	Students see science processes as skills they can use
2.	Students see processes as something to practice as a course requirement	2.	Students see processes as skills they need to refine and develop more fully for themselves
3.	Teacher concerns for process are not understood by students, especially since they rarely affect the course grades	3.	Students readily see the relationship of science processes to their own actions
4.	Students see science processes as abstract, glorified, unattainable skills that are unapproachable for them	4.	Students see processes as vital parts of what they do in science classes
		Creativity	
1.	Students decline in their ability to question; the questions they do raise are often ignored because they do not fit into the course outline	1.	Students ask more questions, such questions are used to develop meaningful activities and materials
2.	Students rarely ask unique questions	2.	Students frequently ask unique questions that excite their own interests, that of other students, and that of the teacher
3.	Students are ineffective in identifying possible causes and possible effects in specific situations	3.	Students are skilled in suggesting possible causes and effects of certain observations and actions
4.	Students have few original ideas	4.	Students seem to effervesce with ideas
		Attitude	
1.	Student interest declines at a particular grade level and across grade levels	1.	Student interest increases in specific courses and from grade to grade
2.	Science seems to decrease curiosity	2.	Students become more curious about the material world
3.	Students see the teacher as a purveyor of information	3.	Students see the teacher as a facilitator/guide
4.	Students see science as information to learn	4.	Students see science as a way of dealing with problems
		Connections & Applications	
1.	Students see no value and/or use of their science study to their living	1.	Student can relate their science study to their daily living
2.	Students see no value in their science study for resolving current societal problems	2.	Students become involved in resolving social issues; they see the relativity of science study to fulfilling citizenship responsibilities
3.	Students can recite information/ concepts studied	3.	Students seek out information and use it
4.	Students cannot relate the science they study to any current technology	4.	Students are engrossed in current technological developments and use them to see the importance and relevance of science concepts

Use of these domains permit specific differences in terms of student learnings in each domain Figures 1 through 5 indicate typical results obtained by twelve exemplary teachers in Iowa who assessed student growth in the five domains when taught in a standard textbook format versus a Science/Technology/Society (STS) framework. In Iowa exemplary teachers are defined as those who develop and implement science programs which are meaningful to students, are developed

around student interest, and are tied to local situations. The ten features of exemplary programs produced by exemplary teachers can be distinguished as those which:

1. students identify problems with local interest and impact;
2. use local resources (human and material) to locate information that can be used in problem resolution;
3. actively involve students in seeking information that can be applied to solve real-life problems;
4. sees learning goes beyond the class period, the classroom, the school;
5. emphasize the impact of science on each individual student;
6. casts science content as more meaningful than something that exists for students to master for tests;
7. de-emphasize process skills *per se*--just because they represent glamorized skills of practicing scientists;
8. emphasize career awareness--especially careers related to science and technology;
9. provide opportunities for students to perform in citizenship roles as they attempt to resolve issues they have identified;
10. identify of ways that science and technology are likely to impact the future.

The results reported in Tables 1 through 5 were obtained from 24 classrooms of twelve Iowa middle school teachers who were judged as exemplary because their programs possessed the ten characteristics above and because they experienced the most success with teaching in such a manner. The twelve STS sections enrolled a total of 365 students while 359 were enrolled in the textbook sections. In all cases the STS students scored significantly higher than textbook sections -- except in the area of concept mastery. In this instance no significant advantages were found either for the textbook or the STS approach.

Teachers who use exemplary practices (like those who utilize STS strategies) are able to stimulate growth in their students in all domains other than concept mastery to a far greater degree than when standard teaching practices are employed. Perhaps it is fair to define exemplary science teaching in terms of its effect upon producing more student learning. The specific practices of teachers are more important than the curriculum structure and the particular science concepts that a teacher may decide students should know. Teacher attention to concept mastery directly may contribute to learning problems in students. In addition, such attention may signal the existence of a less than exemplary teacher.

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Figure 1
Differences in Percentages of Student in Applying Science Concepts in New Situations
When Students are Taught from the Textbook and in an STS Framework

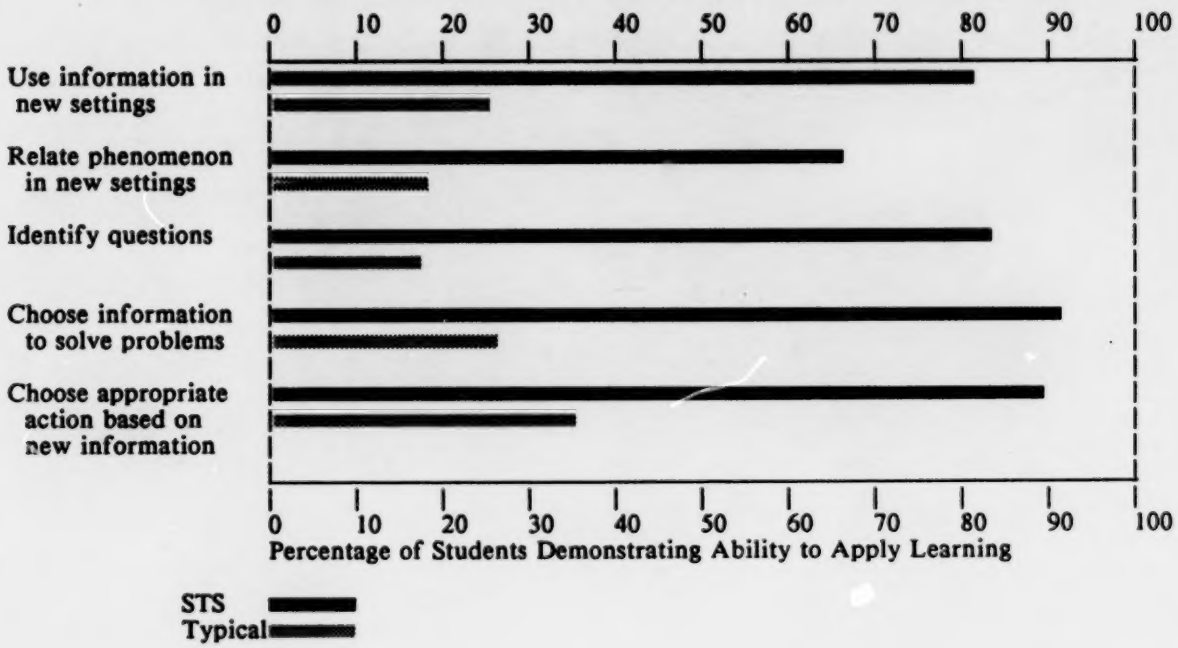
0 10 20 30 40 50 60 70 80 90 100
Use information in new settings
Relate phenomenon in new settings
Identify questions
Choose information to solve problems
Choose appropriate action based on new information
0 10 20 30 40 50 60 70 80 90 100
Percentage of Students Demonstrating Ability to Apply Learning
STS
Typical

Figure 2
Percentage of Students With Positive Attitudes Concerning
Their Science Classes and Science Teachers
for the STS Group and the Contrast Group

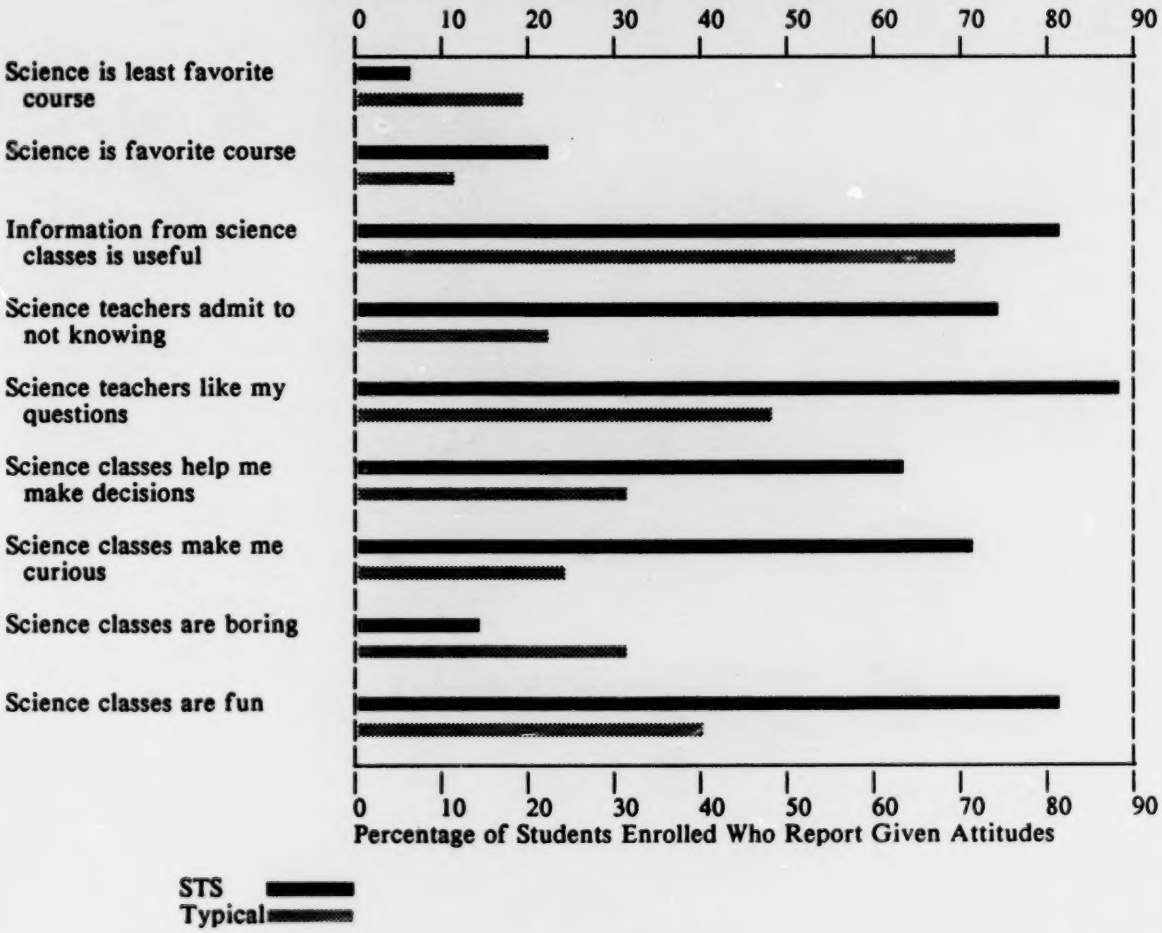
0 10 20 30 40 50 60 70 80 90
Science is least favorite course
Science is favorite course
Information from science classes is useful
Science teachers admit to not knowing
Science teachers like my questions
Science classes help me make decisions
Science classes make me curious
Science classes are boring
Science classes are fun
0 10 20 30 40 50 60 70 80 90
Percentage of Students Enrolled Who Report Given Attitudes
STS
Typical

Figure 3
Average Number of Responses Given by Students in
the STS Group and in the Contrast Group in the Creativity Instrument

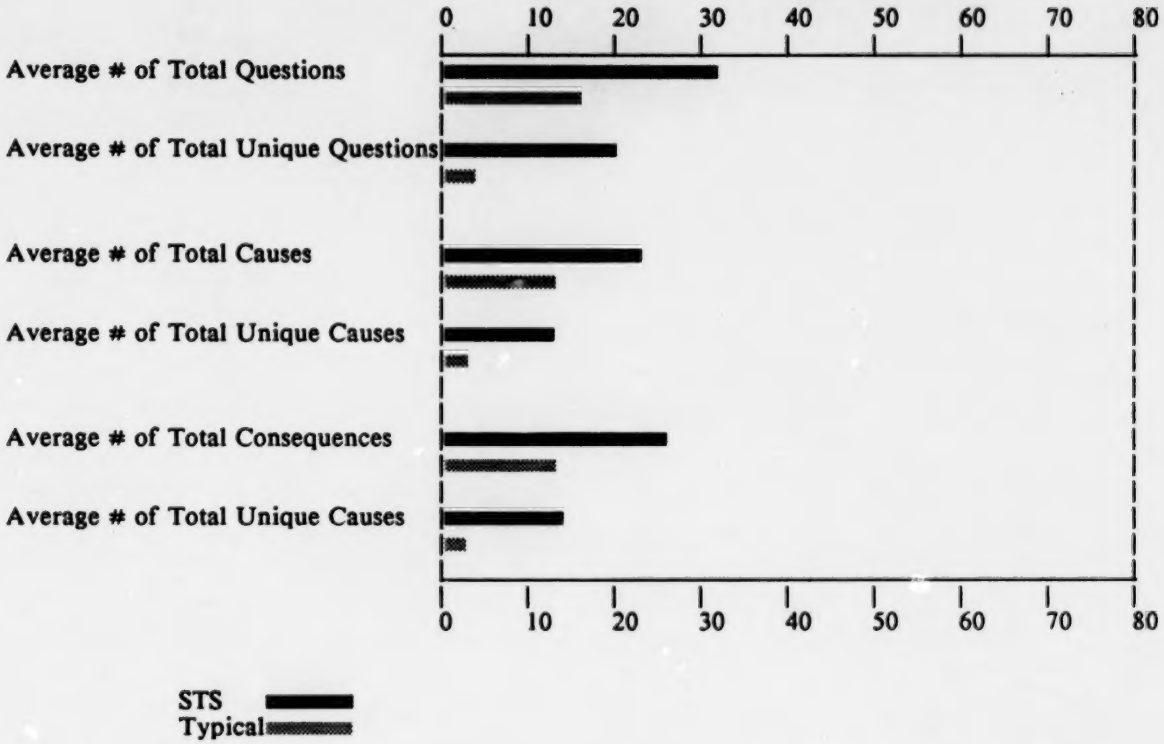

Figure 4

Percentage of Middle School Students who Demonstrate Their Ability to Perform in Fourteen Processes of Science Areas While Enrolled in Traditional Class Sections Versus Students Enrolled in STS Sections

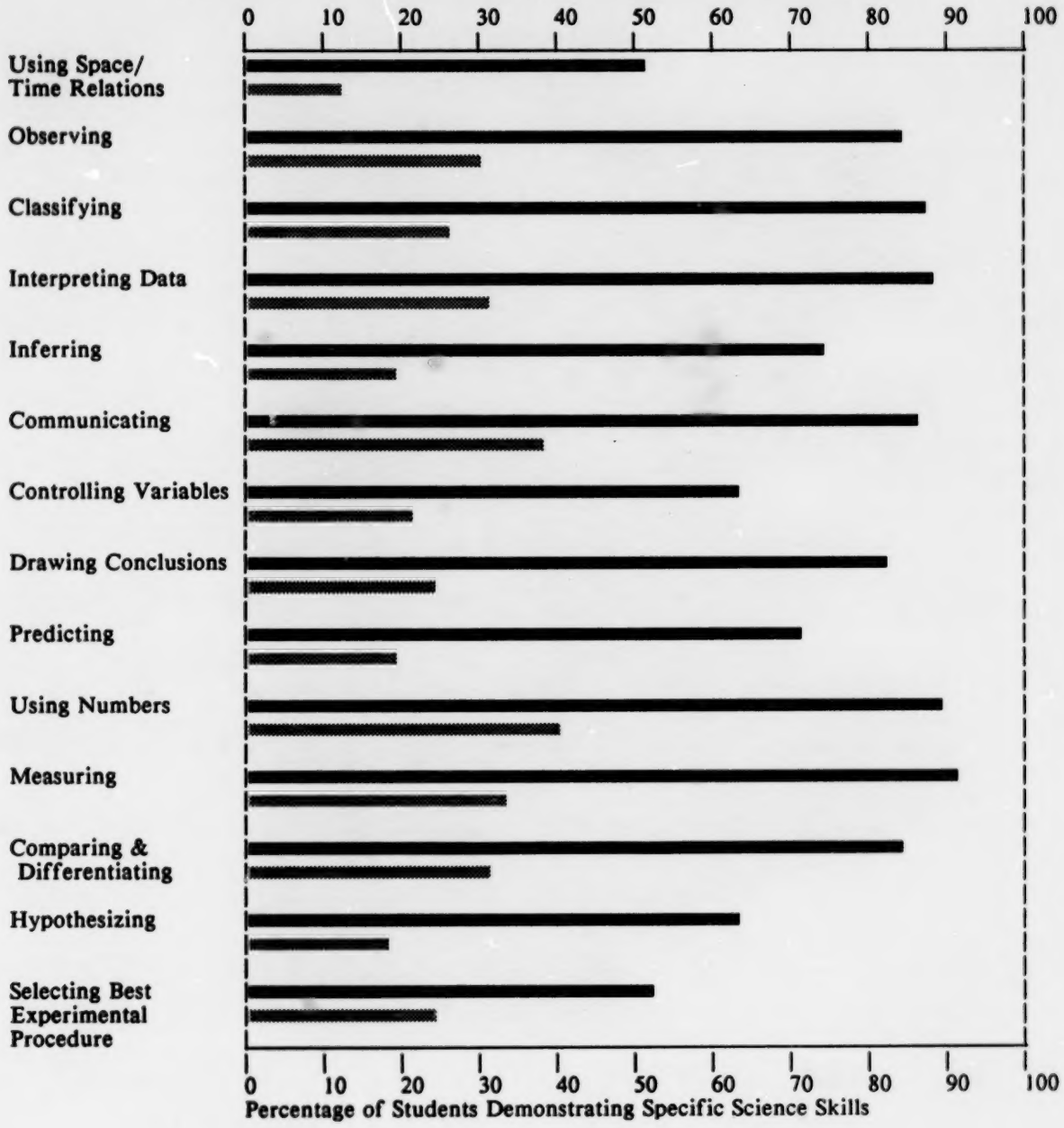

Figure 5

Percentage of Students Selecting Definitions Correctly for Eight Science Concepts After Instruction in Textbook-Centered Courses and STS Courses